

# Environmental Bioremediation and Biodegradation

A MEETING SUMMARY

The Keystone Symposium *Environmental Bioremediation and Biodegradation*, organized by Drs. James J. Valdes, Ananda M. Chakrabarty and Michael Bagdasarian, was held March 6 - 12, 1993 at Granlibakken, Lake Tahoe, California. The abstracts of the meeting were published in the JOURNAL OF CELLULAR BIOCHEMISTRY, Supplement 17C, 1993 (ISSN 0730-2312).

The purpose of the meeting was to bring together the leading scientists and engineers in this diverse area to further dialogue between those conducting basic mechanistic research and those designing fieldable systems, within the context of policy guidelines. The meeting was attended by 110 participants representing industry, academia, and government institutions, from 11 countries on 5 continents. To accomplish the goals of the symposium, the talks were arranged broadly into sessions covering basic molecular genetics, microbial physiology and biochemistry, applications and engineering systems, fate and effects and monitoring, and policy guidelines. In addition, there were poster sessions throughout the week.

One basic tenet of bioremediation is the occurrence of gene transfer between organisms which confers new properties on the recipient. Dr. Robert Miller described studies using virus vectors to transform bacteria and conditions resulting in the lysogenic response. The natural abundance of bacteria and phage particles in aquatic environments make subsequent infection of the bacterial community possible. Molecular genetic approaches also challenged the notion that dichloromethane dehalogenases were relatively recent adaptations to pollutants. Dr. Tom Leisinger's work suggests that it evolved in cyanobacteria and proteobacteria as a defense against oxygen toxicity and is, in fact, very ancient.

Other, more practical, observations include Dr. Michael Bagdasarian's work which showed that genetic regulatory sequences in soil bacteria act differently under starvation conditions than in culture. It therefore follows that one should select for promoters which function under these conditions, i.e., activate systems in soil under starvation conditions. Similarly, Dr. John Reeve looked at genes which cope with growth vs. non-growth (i.e., starvation) conditions. Using methanogenic organisms, he described studies aimed at activating methyl reductase systems under starvation conditions to achieve substrate degradation without growth of biomass. Another example of a practical application of a mechanistic observation was Dr. Gil Geesey's work defining the surface characteristics which stimulate exopolysaccharide production by bacteria. These biofilms often block bioreactors and injection wells, but can also be used to block the spread of plume of pollutants in ground water.

Lignin degradation was an important topic and Dr. Michael Gold's discussion of a proposed mechanism by which white rot fungi degrade lignin and many other aromatic pollutants produced the most incendiary debate at the meeting. Briefly, he proposed that peroxidases depolymerize lignin and the monomers are taken up by the fungi and oxidized to quinone, which is then degraded further by either reduction or methylation. Drs. C. A. Reddy, Steven Aust, and Irwin Gunsalus further elaborated on lignin degradative pathways.

Methanogens are a very diverse group of extreme anaerobes which were also discussed at length. Drs. Tom Leisinger, Mary Lindstrom and John Reeve led much of this discussion which centered on the genetic messages for methyl reductase, and manipulation of substrate specificity by altering nutrient conditions.

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A great deal of time was spent discussing biodegradation of haloaromatic, alkylated aromatic, and methoxyaromatic compounds. Dr. Joseph Suflita focused on a group of gasoline additives while Dr. Ronald Unterman discussed the treatment of TCE contaminated water. The latter used a genetic approach to separate the desired catalytic activity from metabolic regulation by using selective promoters, and also described a sequential aerobic/anaerobic approach to solid phase treatment of waste.

Sensitive monitoring and detection technologies are crucial to both locating toxic wastes and monitoring the condition of microbial systems. Biosensors and recently been developed which detect picogram quantities of chemicals and toxins, and work with a number of these technologies was discussed by Dr. James Valdes. Dr. Ronald Atlas described a modified PCR method to probe for genetic markers in soil as a way to monitor the presence of viable bacteria, and an enzyme amplified oligonucleotide probe technique.

This meeting was unique in its emphasis on applications and engineering, and closer cooperation between microbiologists and process engineers will be critical to the future. This need was evident by the rather spirited debates between these disparate disciplines which emphasized the lack of agreement on many issues from nomenclature to mathematical modeling. Dr. Rodolfo Quintero described a massive water remediation project in Mexico, Dr. Eugene Rosenberg described a successful remediation of an oil contaminated beach in Israel, Dr. Murray Moo-Young discussed airlift bioreactor systems in Canada, and Dr. Robert Hickey detailed plans for sediment remediation at the Savannah River site. The gulf between the biologists and engineers was most apparent in the heated discussion of Monad Kinetics which followed Dr. Leslie Grady's talk on mathematical modeling and system design.

Finally, discussions of policy issues and funding were raised in the final session. Mr. Walter Mikucki from the Army Corps of Engineers presented an overview of the Army's environmental problems and programs, and Dr. Hap Pritchard presented regulatory issues of concern to the Environmental Protection Agency. Many other papers and posters were presented and all had one thing in common other than outstanding quality — a recognition that neither the biologist nor the systems engineer can afford to live in a vacuum if bioremediation systems are ever to be successful on a large scale.

The Keystone Symposia organization will recommend that a second meeting be held in 1995 with Dr. James Valdes as Organizer/Chairman. A relatively greater emphasis will be given to issues of "concurrent engineering" approaches to science and engineering, and workshops to bring the many relevant disciplines together.

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## a Keystone Symposium

## ENVIRONMENTAL BIOREMEDIALTION AND BIODEGRADATION

Organizers: James J. Valdes, Ananda Chakrabarty and Michael Bagdasarian

March 6-12, 1993, Lake Tahoe, California

Sat 3/6	Registration 6:30-7:30pm Social Hour 7:30-8:30pm Dinner Buffet 8:30-9:30pm Orientation	Lobby/Bay Room Granhall Granhall Mountain	P.H. Pritchard Environmental Protect Agency "Measures of Bioremediation Effectiveness in the Field" Coffee Break Joseph Sultta Univ Oklahoma-Norman "Anaerobic Biodegradation of Aromatic Chemicals of Environmental Concern" John Reece Ohio State Univ "Regulated Gene Expression During Methanogenesis"
Sun 3/7	Breakfast 7-8am MOLECULAR GENETICS AND PHYSIOLOGY OF MICROORGANISMS (Session Sponsored by: U.S. Army Research Office) Irwin Gunsalus * Univ Illinois-Urbana Michael Bagdasarian Michigan Biotechnology Inst Ronald Olsen Univ Michigan-Ann Arbor "Gene Manipulation in Soil Bacteria" "Degradation of Alkyl-Substituted Benzenes by Bacteria Functional Under Oxygen-Limited Conditions" Coffee Break Gill Geesey Montana State Univ "Reporter Gene Activity as a Means of Evaluating Exopolysaccharides Production by Bacteria in Reactor Systems" Kensuke Furukawa Kyushu Univ-Japan "Molecular Genetics and Ecology of PCB-Degrading Bacteria"	Granhall Mountain/Lake 5-6pm 6:30-7:30pm Dinner	12pm-4pm Poster Set Up Posters: ANAEROBIC DEGRADATION; AEROBIC DEGRADATION Social Hour 7:30-10:30pm AEROBIC DEGRADATION Thomas Leisinger * Fcd Technical Univ-Zurich "Chlorinated Methanes as Carbon Sources for Aerobic and Anaerobic Bacteria" Burton Pogell Univ Maryland-Baltimore "Streptomyces as Homologous and Recombinant Vehicles for Bioremediation of Pesticides, Nerve Agents, and Other Xenobiotics" Coffee Break Mary Lidstrom California Inst of Technology "Oxidation of Small Fluorogenated Solvents by Methanotrophs;"
Tues 3/9	Breakfast 7-8am DETECTION AND MONITORING 8:30-12pm	Granhall Mountain/Lake	James J. Valdes * US Army "Biosensors for Monitoring Chemical Pollutants in the Environment" Gary Sayler Univ Tennessee-Knoxville "Molecular Strategies in Biodegradation Process Monitoring and Optimization" Coffee Break Ronald Atlas Univ Louisville "Molecular Methods for Detecting and Monitoring Microorganisms" Betty Olson Univ California-Irvine "Gene Occurrence and Expression in the Environment" Anne Summers Univ Georgia-Athens "A Biosensor for Mercuric Ion and Metallic Mercury Vapor"
12pm-4pm 4-6pm 5-6pm 6:30-7:30pm 7:30-11pm	Poster Set Up Posters: MOLECULAR GENETICS AND PHYSIOLOGY OF MICROORGANISMS; LIGNIN AND CELLULOSE DEGRADATION Social Hour Dinner LIGNIN AND CELLULOSE DEGRADATION Michael Gold * Oregon Grad Inst "Degradation of Chlorinated Phenols and Chlorinated Dibenz-P-Dioxins by Phanerochaete Chrysosporium" Steven Aust Utah State Univ "Biodegradation of Chemicals by White Rot Fungi" Coffe Break C. Adinarayana Reddy Michigan State Univ "Lignin-Degrading Enzyme System of Phanerochaete Chrysosporium: Molecular Biology and Role in Organopollutant Degradation"	Bay Room Bay Room Bay Room Granhall Mountain/Lake	8:30-12pm Social Hour 7:30-11pm Dinner APPLICAIONS I
Mon 3/8	Breakfast 7-8am ANAEROBIC DEGRADATION (Session Sponsored by: U.S. Army Research Office) James Tiedje * Michigan State Univ "Anaerobic Metabolism of Chlorobenzoates, Phenols, Biphenyls and PCP by Novel Anaerobes" John Loper Univ Cincinnati "Bacterial Isolates, Recombinant Yeasts, and Microbial Systems for Degradation of Hazardous Compounds"	Granhall Mountain/Lake	Eugene Rosenberg * Tel Aviv Univ Ronald Unerman Envirogen "Biological Treatment of Chlorinated Organics-Laboratory and Field Studies" Daniel Abramowicz General Electric-NY "PCB Biodegradation in the Laboratory and in the Environment" Coffee Break Bernard Wirtholt ETH "Biodegradation of Aliphatic and Aromatic Compounds en Route to Useful Syntheses" Joseph DeFrank US Army "Biochemical Demilitarization of Chemical Warfare Agents"

**SPEAKERS**

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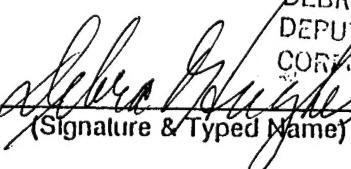
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